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Development of Grain Standards in Developing Countries

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INTRODUCTION

The increasing world population has put new pressures on agriculture and agricultural systems, not only in the obvious, more people need more food, but also in other ways, such as marketing that food. It will not help for the farmer to produce more if that produce cannot be moved through the market to the consumer in an efficient way. This report is intended as a guide -- not a specific set of recommendations for each and every case, but only a guide -- to those who would develop or modify the present, often inadequate marketing systems, with particular reference to the inspection and quality determination of the produce.

The literature dealing with this topic is small and scattered. Yet interest in the subject grows keener with the passage of time. How are quality factors developed? How are they useful, anyway? How does inspection proceed? How can it be made fair, credible and intelligible to all concerned?

These are a few of the questions that this report will attempt to deal with. Naturally, each marketing system must be evaluated individually, and developed or modified to meet the needs of the producers, processors, and consumers within that system. There are, however, similarities common to all, or nearly all, marketing systems and to the role that grain inspection will play in them.

Grain quality is recognized in the marketing system. Through observations of marketing systems in developing

countries we have found the quality of grain to be generally high. This is due, in part, to the processing techniques practiced in these countries and also to a large extent to consumer demand.

The consumer has learned to expect a certain quality level in the grains they buy. If the grains do not meet these levels they are generally unwilling to pay the same price for this lower quality grain. This is evidenced by the pricing structure found in most market places. The only time the prices are uniform on all grains of the same class is when the condition or quality of this grain is uniform.

Quality determinations can only be made on grains of similar class. To compare beans with corn for example would be senseless due to the growing characteristics and end usage. However if the system is developed properly then each grain can be evaluated on its own merits and its value determined as compared to grains of its own class.

The inspection system described in this report will be developed around quality factors now recognized as important and apply them so they can be understood by any interested persons. The system will have incorporated in it rewards for superior quality and discounts for grains of inferior quality according to the value of each quality factor. For the farmer to produce grain of high quality an incentive must be present. This incentive can be provided through an inspection system if the system is based on quality factors that are recognized as important in the market where the grain is being sold.

To develop an inspection system that will be meaningful in the marketing of produce we first need to look at the role inspection will play in the buying, selling, transporting, storing and processing of agricultural produce, in this case primarily cereal grains and edible beans, peas and pulses. The worth of any inspection system will depend on the factors used to determine quality and the values placed on these factors.

REVIEW OF LITERATURE

When developing an inspection system, a first important step is to understand the nature and purpose of standardization. In any marketing system sorting is done by the individuals in the market. Taking grain as an example this sorting will be done at different levels throughout the marketing channels. The producer may hold back some of his grain for personal use as food, feed or seed. The merchant will buy grains according to what his customers demand or are willing to buy. The processor will select grains with the qualities that best suit his use and the consumer will choose from what is available, the product that best fits their need and financial limits. Separating commodities according to their usefulness or quality is not a new concept.

Traditional market transactions are made on a personal basis. Thus commodity inspection by a third party is not needed as the buyer personally inspects and chooses the produce best suited to his or her needs. In situations such as this a commodity inspection system may have little effect or possibly little value. As the volume of grain going through a system increases and the distance the commodity is transported increases the usefulness of some system for quality determination becomes more evident, and can be used to the advantage of all participating in the marketing system. The fact that an inspection system is not used throughout the market system does not negate its usefulness where it is used,

nor the possibility of beneficial effects extending into those parts of the market where it isn't used.

Quality determination could be called the official inspection and classification of produce according to its quality or value. It is this third party inspection done by government or a disinterested party that we are concerned with. This is separate from the inspection practiced by buyers and sellers in the marketing system. With this private sector already practicing inspection and sorting it may be questioned as to why a third party inspection is needed and, if there is a need, when and under what conditions would this need arise? To answer this question consider the benefits that can be gained from a quality determination system.

1) Standardized grains are priced more fairly than non-standardized grains. This tends to stabilize marketing practices by providing consistent and dependable qualities.

2) Market price quotations based on grades assist producers and merchants in marketing their produce advantageously.

3) The application of standards shows causes for market discounts and thereby indicates ways of quality improvement thus rewarding those that maintain quality in their produce.

4) Inspection facilitates the economy of bulk transportation and storage. Thus eliminating the need for preserving the identity of each lot of grain.

5) Standardization and inspection facilitates the financing and trading on the basis of warehouse certificates.

6) When a lot of grain is represented by a certificate of inspection trading without personal inspection is possible.

S. J. Duly of the City of London College, in his book, Grains (7), made this comment of the benefits of standardization:

> "The advantages of the grading system are many. It is essentially a farmer's system. It is his safeguard. Grading takes place in the country of production and it provides the required incentive to the farmer to farm well, since he has the assurance that his return will be determined by the quality of his crop. His grading certificate provides him with bank credit immediately. Then grading is an absolute prerequisite to bulk handling. If grain is not graded it cannot be bulked with other grain, but must retain its identity and be sampled frequently for selling purposes. The immense economy of the terminal storage system is only possible after dependable grading. Next it provides the basis on which organized marketing with future sales and hedging alone becomes possible. This forms the most machinery for financing the crop, paying cash to the farmer months before the grain is exported, holding it, transporting it and getting it to the miller. Finally, it provides the last buyer with a standard article upon which he may depend, in the same manner that buyers depend on the trade mark of manufactured goods of reputable firms."

Variation in Quality

Quality is defined as the sum of the attributes of a product which influence its acceptability to many buyers (6). Before attempting to define the quality of grains the purpose for which it is required must be known. Factors which may make a grain less desirable to one buyer or for one usage may have little affect on another buyer or usage.

To the producer the yielding ability of the variety, its disease resistance and general growing characteristics are important quality factors in deciding what he will plant. To the miller, quality means good flour yield, low moisture content, ease of processing and soundness of grain. To the

consumer the important quality factors are cooking properties, texture, taste and aroma.

Quality variations of agricultural produce occur due to the nature of production. Differences in weather, soil conditions, climates and such will cause irregularities within and between different varieties of the same grains. Because agricultural products are not subject to the precise methods of manufacture, more characteristic of industrial products, it is difficult to get exact uniformity. In agricultural products there are many variables such as size, shape, texture, taste, color, aroma, moisture content, nutritional level, keeping qualities, etc., which can not be easily controlled. Some agricultural commodities, such as livestock, are difficult to describe fully and therefore are usually subject to personal inspection by the buyer. Commodities such as food grains and fibers can be sampled and described. Their trading can then be done on the basis of the description and/or samples.

Providing that the grains in question can be sampled and described in a satisfactory manner, what criteria should be used to make a quality determination? R. L. Kohls and W. D. Downey in their book, Marketing of Agricultural Products (10), propose the following criteria which could be used to judge the adequacy of standards:

1) Standards should be built on characteristics the users consider important and those characteristics should be easily recognizable. Grades must be orientated to user opinion of value and not that of a few technical experts.

2) Standards should be built on those factors that can be accurately and uniformly measured and interpreted. If the major part of a standard consists of subjective measurements, uniform application by different graders or at different points will be very difficult. Excessive quality variation within a grade reduces the usefulness of the grade itself.

3) Standards should use those factors and that terminology that will make the grades meaningful to as many users of the product as possible.

4) Standards should be such that each grade classification includes enough of the average production to be a meaningful category on the market. Though grading standards should be consumer-oriented, they cannot ignore the real facts of production. Consideration must be given to the quality of the product produced. It is of little value to have a standard for the top quality set up in such a fashion that very little of the actual production can meet it.

5) The cost of operating the grading system must be reasionable. Absolute uniformity at any price is not a feasible goal.

An inspection system will be influenced by the time of inspection, inspection procedure, and quality factors. In developing an inspection system these things must be kept in mind and studied to determine if they are acceptable quality judgements on which to classify the grain in question.

<u>Definitions</u>

Throughout this report certain quality factors will be referred to in relation to grain quality. To help eliminate

confusion it would be best to define these terms so they can be referred to as needed. Many of the definitions are the ones used in the United States Grain Standards (9). These definitions are in common with many other inspections systems throughout the world.

Moisture content - The amount of water held by the grain. Moisture content is usually expressed as weight of water per unit weight of wet grain (wet-weight basis) or weight of water per unit weight of dry grain (dry-weight basis). In trade and industry moisture content wet-weight basis is most often used and will hereafter be referred to as such.

Foreign material - Material mixed in the grain that is other than the grain in question. This will consist of weed seeds, straw, chaff, sand, dirt, stones, other grains and other material.

Insect damage - From the U. S. Standards. 1) Kernels which bear evidence of boring or tunneling indicating the presence within of insects, insect webbing, or insect refuse; and 2) Kernels in which noticable weevil-bored holes have been eaten and in which webbing or weevil refuse still remain, are damaged kernels. Note: Kernels which have been partially eaten by insects or rodents but which are entirely free from refuse, webbing, or insects or other forms of damage are not damaged.

Test weight - Weight of a given set volume of grain. In the U. S. it is expressed in pounds per bushel. In the metric system it is expressed as kilograms per hectoliter.

Mold damage - From the U. S. Standards for corn. A kernel of corn, the germ of which is affected by blue-eye mold, shall be

a damaged kernel. Kernels of corn having surface mold growths which have not penetrated the kernel sufficiently to injure them shall be considered as sound kernels, provided the kernels are otherwise sound.

Sprouted kernels - From the U. S. Standards. Kernels which have the germ end broken from germination, and kernals which have sprouted, including the kernels from which the sprouts have been broken off, are damaged kernels.

Heat-damaged kernels - Kernels and pieces of kernels which have been materially discolored and damaged by heat (including heat of respiration).

Cracked kernels - Kernels that have had the seed coats or endosperm cracked by mechanical means or by drying too rapidly with excessive heat.

Broken kernels - Pieces of kernels which are less than 3/4 of a whole kernel.

Present Grading Systems

U. S. Standards - In 1916 the United States Grain Standards Act was passed providing in part for 1) the establishment of official grain standards, 2) the Federal licensing and supervision of work of grain inspectors and 3) the entertaining of appeals from grades assigned by licensed inspectors. These standards are in effect for wheat, corn, barley, oats, feed oats, mixed feed oats, rye, grain sorghums, flaxseed, soybeans and mixed grains (8). Standards for rice have also been adopted.

Quality tests are run on the various grains which will determine the grade the grain will fall into. For example,

the factors relative to wheat quality are test weight per bushel, damaged kernels, foreign material and wheat of other classes. Each class of wheat is divided into five numerical grades and a sixth sample grade. These grades specify the minimum test weight per bushel and maximum limits of the remaining factors. The "sample grade," however, covers wheat which does not meet the requirements of the five numerical grades and contains moisture above the acceptable limit. Dockage and moisture content do not form the basis of each of the five numerical grades separately. In addition, there are or have been special grades (for example, tough wheat, smutty wheat, garlicy wheat, weevilly wheat, ergoty wheat and treated wheat).

Corn standards are based on roughly the same quality factors as wheat with some exceptions. With corn the moisture content is used as a grading factor, that is the moisture content of corn may be used to determine which of the five numerical grades the corn may fit. Broken corn and foreign material are combined to make one quality factor of its own. The allowable amount of each of the quality factors and how they effect the grade of corn are also different than the limits set for wheat. Other grains are similar with variations of quality factor definitions and also the limits of the quality factors allowed in each grade.

Another grading system that has some use in the international trade is the F.A.Q. or Fair Average Quality system. This system as used in Australia is described by Shah in his thesis on <u>World Wheat Standards</u> (11).

"The quality standard for wheat prevalent in Australia is known as F.A.Q. (Fair Average Quality) which is fixed in different states each year based on the representative samples of the season's crop. It is simply the average sample of the states' crop. These samples are drawn from different wheat districts in the state, given an appropriate statistical weight, mixed together and then the F.A.Q. is the average sample drawn from the representative mixture of the samples of the state wheat crop. The F.A.Q. is fixed by the Corn Trade Section of the Chambers of Commerce in the various states. These Chambers of Commerce are private organizations, those located in big cities, generally have a grain section which deals with the fixation of the F.A.Q. standard. It represents the standard for the state for the season and may vary from season to season and from state to state during the same season."

"The domestic sales in Australia generally take place on F.A.Q. basis, all wheat is pooled and consequently sold as such. In foreign trade F.A.Q. standard samples for the season are dispatched to buyers before purchase. In the United Kingdom, which constitutes the largest single buyer of Australian wheat, these samples are sent to London where they are 'adopted' by the London Corn Trade Association. Should the cargo happen to fall below the standard, appropriate allowances are deducted from the settled price through a system of arbitration."

Other systems were observed in countries such as the Dominican Republic and Columbia which used a system similar to what the United States uses. That is, they separate the grains into grades based on quality factors. The system in Columbia adjusts

each sample for moisture and foreign material and then uses any other factors, such as damaged kernels, moldy grains, to determine the numerical grade.

Tunisia on the other hand, does not use the system of numerical grades. Rather each quality factor has a discount connected with it according to the amount that factor falls below a set tolerance or limit. With bread wheat, for example, the tolerance for impurities or foreign material is 1%. The following table is used to calculate the adjustment for impurities higher than this.

Impurities (13)

(Tolerance: 1%)

1.01 - 2% = Dockage 10 m/Ql*

2.01 - 3% = Dockage 80 m/Ql

3.01 - 4% = Dockage 120 m/Ql

4.01 - 5% = Dockage 160 m/Ql

*2.30 U. S. dollar = 1 dinar = 1000 milliems (m)

1 Quintal = 100 Kg

Thus the grain is not put into a grade designation but rather each quality factor is adjusted according to how it affects the quality of the grain. Other quality points such as insect damage, moldy grains, etc., carry discounts according to their value. Moisture is also discounted for but a premium is given for low moisture content.

Most countries visited where some grain inspection system was in use, had means within the standards for inspecting the bulk shipment as a whole. Using the standards from Costa Rica (5) as an example (this would cover the majority of other

systems as well) a preliminary analysis is carried out on the bulk to determine A) temperature, B) odor, C) infestation.

The recommendation for each of the points are as follows:

A) Temperature should be normal.

B) If objectable moldy or sour odor is noted the lot should not be accepted. If a certain product shows signs of having been treated by some chemical product, it should not be received until the technicians of the National Production's Advisory have been consulted.

C) If, in the preliminary analysis, indications of live infestation appear, the particular product should not be accepted at the agency level (purchasing point) except in the plants which have the authorization of the administration.

Table 1 compares quality factors used in the inspection systems in a number of countries. As can be seen, many of the same quality factors are used in the different countries represented. Although the quality factors used in many inspection systems are similar, the way they are defined and implemented vary causing differences in inspection systems throughout the world. For example, while we were in the Dominican Republic, we found that tolerances allowed for the factors of #1 corn were approximately the same as #3 corn in the U. S. A. When we asked about this we were told that the normal in-country production fit these conditions so they could see no reason to

TABLE 1. COMPARISON OF DIFFERENT GRAIN QUALITY FACTORS USED IN OFFICIAL GRAIN INSPECTION SYSTEMS IN VARIOUS COUNTRIES

Country	Moisture Content	Foreign Material	Insect Damage	Mold Damage	Other Damage	Contrasting Classes	Test Weight	Broken Kernels	Odor
	Wheat								
Colombia	X	X	X	X	X	X	X	X	X
Tunisia	X	X	X	X	X	X	X	X	X
U. S. A.	X	X	X	X	X	X	X	X	X
	Corn								
Colombia	X	X	X	X	X			X	X
Dom. Rep.	X	X	X	X	X			X	X
U. S. A.	X	X	X	X	X	X	X	X	X
	Rice								
Colombia	X	X	X	X	X	X		X	X
Costa Rica	X	X	X	X	X	X		X	X
Dom. Rep.	X	X	X	X	X	X		X	X
U. S. A.	X	X	X	X	X	X	X	X	X

use the same criteria as the U. S. A. and have no grain that would meet the #1 and #2 grades. It should be noted that foreign material and moisture did not enter into the grade of corn. These were discounted according to the amount present.

Implementation of factors is another area where great diversity could be found even within one country. To inspect grain on an unbiased basis all inspection points within the system would require about the same laboratory facilities and equipment. The inspectors would need up-dated training and the equipment in the laboratory would need periodic maintenance and calibration to insure similar results throughout the inspection system.

Observations at some inspection points indicate the lack of use of some equipment or techniques. Things such as broken equipment, moisture meters not calibrated and equipment covered with dust indicating lack of use. Also encountered were technicians unfamiliar with inspection techniques. All of these observations point to the need for further training of staff and better equipment maintenance and calibration.

Experiences of this type prompted us in our work to seek simple quality factors to be used in an inspection system and to apply this in as simple a manner as possible. This will help to bring the inspection done throughout the system to a more equal and unbiased basis.

Sampling

An essential step to any grain inspection system is obtaining a correct and representative sample. Uniform and unbiased sampling must be carried out to ensure the credibility of the

inspection system. If trading is to take place on the basis of inspected samples then the buyer must be satisfied that the sample is truly representative to give him confidence in buying without personal inspection. All later analysis depends on how well the sample is taken and handled. No matter if the lot of grain is bulk or sack, in carloads or cartloads, the inspection of that lot of grain is dependent on a representative sample.

The book Storage of Cereal Grains and Their Products, by C. M. Christensen (4), contains a chapter on sampling, inspection and grading of grains that deals with the equipment and techniques which have been developed and used in the grain industry. The chapter points out a few important ideas to be kept in mind when developing sampling procedures.

The equipment used in taking a sample will depend on the size of the shipment received and somewhat on the method of handling when unloading. The sampling should be done so that the sample will represent different portions throughout the load. With sacks, a sack trier is used and different sacks are probed as the grain is being unloaded. With a bulk truck a probe can be used that would sample the load at different depths to obtain a portion from each depth and at different places in the bulk which would then make up the total sample. It is also possible to take a number of samples as the truck or railcar is being unloaded and composite these to represent the load. In either case the personnel doing the unloading should keep watch that the load is uniform and any irregularities are reported.

Once the sample is composited it must be reduced to a proper size for inspection. Different grains will require different sample sizes. A 100-gram sample of wheat would be much more difficult and time consuming to inspect then the same weight sample of corn due to the size difference of the kernels. Therefore a sample size must be established for the different grains in question. A listing of the recommended sample sizes used when inspecting grain in the United States is shown in Table 2. From this a relationship between the different grains and their representative sample size can be found. Choosing the proper sample size will simplify the inspection process considerably. To reduce the composited sample to the working sample; quartering, Boerner divider or similar techniques can be used.

Samples must be handled properly to ensure the correct inspection results. If the sample is allowed to become wetter or dryer or foreign material is mixed or removed after it has been taken from the lot of grain then the inspection will be meaningless. If the moisture content cannot be determined rapidly then the sample should be put in a sealed container and protected from the moisture in the air.

When sampling a lot of grain, it must be kept in mind that the grain is rarely a homogeneous mixture. The problems relating to sampling are due mainly to this fact. To illustrate this point Christensen (4) quotes from an article by Watson (1969), "Grain cycled between bins several times and tested for homogeneity (degree of mixing) between cycles shows that, beyond a certain point of mixing, homogeniety of the grain

does not increase. In our case, no increase in homogeneity occurred after three cycles of mixing. The data indicates that grain is probably never a homogeneous mixture and this contributes, significantly, to the problem of accurately sampling a grain lot."

To help overcome this difficulty of non-uniform grain lots, enough samples must be taken from different locations in the lot to represent the lot as a whole. These samples must then be mixed and redivided to give the working sample of the proper size. If a probe is used in a bulk of grain, each probe should be inspected to see that it compares to probes from other parts of the bulk. If there is a portion of the lot different from the other parts, then its size and value should be determined by additional probings. For example, if a bulk of grain is probed and, upon comparing the probes, it is found that one probe is much different than the others then further probes around this should be taken to determine how the area in question will affect the rest of the bulk.

When inspecting small quantities of grain the possibility of complete inspection should not be overlooked. Burke and Pfost, in a report on the Rwanda storage situation (3), indicate that whole quantity inspection is done on grains before they are bought and stored in the community storage units. "To practically eliminate foreign material no quantitative standard was set but the following procedure was adopted. Each basket of grain was poured out on an inspection screen which allowed fine material to fall through. Any large foreign material was picked out. Farmers showed no resistance to this

procedure. All grains are hand hulled or threshed so farmers can easily deliver very clean grain and are accustomed to buying, selling and using clean grain."

This method may work well in areas where moisture content and foreign material are the only quality factors that vary to any extent. That is, if all but only a very small portion of the grain received at a buying point is sound, undamaged grain, then this simplified method may be perfectly acceptable. On small lots, a few sacks for example, the foreign material is removed on the spot. Moisture content could then be determined and adjustments made as needed.

TABLE 2. MINIMUM QUANTITY OF GRAIN IN ANALYTICAL PORTIONS RECOMMENDED FOR INSPECTION WORK (GRAM)*

Grain	Wheat	Corn	Sorghum	Oats	Soybeans	Rice
Sample Size	50	250	30	30	125	50

*Larger samples may be needed for moisture tests using meters.

METHODS

Traditional and village level marketing systems played an important part in developing the ideas of this report. To gain an insight into how these markets work two months were spent in four Latin American countries observing the methods by which grain travels through the market channels. This, along with observations made in North Africa, Central Africa and some Middle Eastern Countries gave a wide range of experience from which to draw.

One of the objectives in visiting the different marketing centers, both public markets and governmental organizations, was to see what grains are sold through these markets and their condition. One wouldn't expect all markets to be the same due to the types of crops grown, growing conditions, consumer demand and eating habits. As a general observation we found the quality of the grains in the public markets to be a bit higher than the grains in the governmental organizations. There are exceptions to this but it indicates that people in the markets do recognize grain quality. This is also evidenced by the price difference found throughout the market place, that is, lower quality grains were generally cheaper. It was also noted that the range in quality generally wasn't large. The whole idea of separating grains according to quality isn't new.

These markets visited ranged from the larger central markets of the major cities to the smaller markets of the outlying villages. Some were permit market places with shops being run

by a proprietor and others were weekly markets with the producer bringing in grain to be sold that day. Along with this, interviews were held with merchants and goverment officials involved in the marketing of grains. Our feelings were that for an inspection system to be useful it must be able to relate to a majority of the marketing channels. To develop a system that benefits only a special part of the grain trade could be detrimental to the over all development of the agricultural community.

Through study of the market places we found a number of points or factors that were generally accepted as relating to the quality of the grain. These factors included moisture content; insect damage and infestation; foreign material; broken grains; moldy grains; and off colors, flavors or odors. How each of these factors would effect the the value of the grain would depend on the type of grain, its use and to some extent on supply and demand. Of course, variations were found from country to country and even between regions within a country. For example people of the coastal region of Ecuador would pay a premium price for white rice as compared to rice discolored due to heating. The mountain people of the same country, on the other hand, would pay the same price or even prefer the discolored rice to the whiter rice. The pricing structure did not recognize this as a lower value grain.

A brief discussion of each of the quality factors here would help explain how they could be used to help evaluate a lot of grain. These factors must be as objective as possible and simple to evaluate. One point of much dispute when

inspecting a product is the human judgement involved. In traditional marketing channels this factor is dealt with by personal arbitration between buyer and seller.

To develop an inspection system based solely on mechanical measurement of objective quality factors would however involve the use or possible development of highly technical and expensive equipment. This would add greatly to the cost of the product, this additional cost would not only reflect the cost of the equipment but also the training of technicians qualified to use it. With this in mind it is recommended that the factors used in representing a quantity of grain be simple and easily determined.

QUALITY FACTORS

Moisture Content

The importance of moisture content in grains is widely recognized by farmers, merchants and processors. Excessive moisture not only adds to the total weight of the grain but also affects its storability. Both of these points are of concern to the buyer and must be accounted for when purchasing grains. Because of the importance of moisture content, most marketing systems have developed means to recognize the moisture condition of the grain. The method of determination varies from place to place and with different types of grains. In the Dominican Republic, we saw people biting rice kernals as a test for moisture. Some other methods observed were dropping a hand full of beans back into the container and listening to the sound they make, rubbing kernels of grain together apparently feeling the resistance between kernels, chewing a handful of grain, and simply sticking one's hand into the grain to see how it feels. With experience these methods can give a fair indication as to whether the grain is of a safe moisture range for storage. For example, the merchant observed biting rice to test moisture had separated two different bags, one was satisfactory and the other was wet. When tested with our portable moisture meter we found that one sample had a moisture content of 10% and the other was 18%. With his method the merchant knew that something would have to be done with the wetter grain soon to keep it from spoiling.

In a country like Tunisia where the climate is dry the moisture content of the grain isn't of great concern. The grain is harvested dry and unless outside moisture is added it will remain dry. In rainy, wet climates where the relative humidity is high, the moisture content of the grain becomes a much more important factor.

Moisture content is defined as the amount of water held by the grain. Moisture content is usually expressed as weight of water per unit weight of wet grain (wet - weight basis) or weight of water per unit weight of dry grain (dry - weight basis). In trade and industry moisture content wet-weight basis is most often used and will hereafter be referred to as such.

To compensate for the amount of water held in the grain, sales can be made on a dry matter basis or adjusted to a common moisture content. Any given weight of grain at a given moisture can be converted to the weight at a common moisture wet basis by the following formula.

$$W_1 = \frac{W_2\ (100 - M_2)}{100 - M_1}$$

W_1 = Weight of grain at desired moisture

W_2 = Weight of grain at moisture, M_2

M_1 = Desired moisture content

M_2 = Moisture content of grain

If, for example, corn is to be sold on a 13% moisture basis then 500 Kgs of corn at 17% moisture would convert as follows:

$$W_1 = \frac{500\ (100 - 17)}{100 - 13} =$$

W_1 = 477 Kgs at 13% moisture.

This new weight can then be used to calculate the percentage discount from the equation:

$$D = \frac{W_1 - W_2}{W_1} \times 100$$

D = Discount, %

W_1 = Original Weight

W_2 = Correct weight

For the 500 Kg of corn then the discount would be 4.6% to account for the excess water.

$$D = \frac{500 - 477}{500} \times 100 = 4.6\%$$

This equation makes adjustments for the amount of water only. A charge for drying would be made according to local conditions and costs. A simpler but somewhat less accurate method of accounting for the weight of water in a sample would be to discount 1.15% for each 1% of moisture above the desired moisture content, and a premium of 1% for each 1% of moisture below the desired level.

Using the same 500 Kg of corn the difference between the moisture content and the base of 13% is 4%. Then this difference (4%) x the adjustment factor (1.15%) yields a total adjustment of 4.6%. The adjustment factor (1.15%) may have to be recalculated for base moisture contents other than 13%. A drying charge would be made separately.

A third way of adjusting for excess moisture would be to incorporate the drying charge with the weight adjustment. The

amount of this charge would depend on drying facilities and local costs. For example in Manhattan, Kansas, U. S. A. for the crop year of 1976 for grain sorghum the cooperative elevator was charging \$.92/metric ton per one percent of moisture between 18% - 14% moisture. Above 18% the charge was \$.37/metric ton for each one percent of moisture. An additional charge of 1.5% per one percent moisture was taken to compensate for water loss and shrink due to handling. Then, to dry one metric ton of grain sorghum from 18% to 14% would cost \$3.66. With the price of milo at \$66/metric ton the drying charge would amount to 5.6% of the price, or 1.4% for each moisture point. Add to this the charge for moisture loss and shrink for a total adjustment of 2.9% per one percent of moisture. If the price of grain varied widely throughout the year this system of accounting for moisture may not be ideal.

When the moisture content of the grain is below the base limits a premium would be necessary to compensate for the weight loss due to over dry grain. By making this adjustment the seller has no incentive to add water to the grain to bring it up to the base moisture level.

Another important consideration of moisture content is its effect on the handling and storability of grain. Damp grain flows less readily than dryer grain, a factor that must be dealt with when conveying grain. But more important is the rapid deterioration of the grain at higher moisture levels. The increase in the rates of growth of mold, insects and mites as well as the rates that chemical and physical change take place are related to the increase in moisture content.

(Temperature is also a contributing factor.) Any grain that isn't to be used immediately must be at a moisture and temperature level that will prevent it from going out of condition before it is used.

Grains are normally dried to a moisture level low enough to prevent deterioration. This idea is generally known by anyone experienced with the handling of grains and is readily accepted as a quality point when marketing grains.

It is suggested that a safe storage moisture content (See Table 3 and appendix II) be determined for a product and sales of grains be adjusted to this level. This will account for grains that are wetter than or dryer than the safe level. It will be left up to the merchant or government buying policy to determine what moisture range will be accepted at the buying point. This will depend on drying facilities available, storage time and intended use of the grain. By adjusting all sales to a common moisture base there will be no incentive to increase the weight by the addition of water to the grain.

If moisture is to be used as a quality factor an objective method of determination should be used. The traditional method of biting or feeling the grain works fine on the local market level where there is personal interaction between the buyer and seller. Here the moisture condition can be adjusted through personal arbitration to the satisfaction of both. However if an adjustment is to be made on the basis of actual moisture levels present then an accurate method must be used to make the determination.

TABLE 3. SAFE MOISTURE LEVEL FOR ONE YEAR STORAGE*

Grain	Moisture Content
Wheat[2]	13%
Corn[4]	13%
Sorghum	13%
Rice, Polished	14%
Rice, Rough	12%
Soybeans	11%

*Grain should be checked periodically to assure no change has taken place.

There are several methods for determining moisture levels. Among the most accurate is the air oven method. However, due to the time and equipment involved, the use of electric moisture meters may be adopted. With the proper care and maintenance of the meters and the training of the operators, sufficiently accurate results can be obtained. The air oven method could be used to calibrate and adjust the meter and to periodically check the accuracy. These meters, if properly introduced, will be accepted by the people involved. In Rwanda, the Catholic Relief Services reported having good acceptance among the farmers participating in their storage program.

Foreign Material

Foreign material is quite commonly found mixed with grains. This will consist of anything from sand and rocks to chaff and stalks. The markets in Port au Prince, Haiti, were one of the few places observed where the grains were basically free of foreign materials. The reason for this is probably the harvesting techniques used. Much hand separating is done, such as hand shelling corn, where the grains can be kept clean and free of extraneous materials as they are processed.

Markets in Iran and other places where grains are commonly threshed on the ground and winnowed to separate the chaff, will have sand, stones and chaff mixed to some extent in the final product. This cannot be prevented without more sophisticated threshing and cleaning equipment. This does not however say that the presence of foreign material is accepted without penalty. Reasonable amounts are tolerated in the market place but

adjustments are commonly made to grains that have excess foreign materials.

Processors are aware that non-grain materials are of no value to them. Any material that millers separate from the grain they are milling will be a loss to them. This material is being bought at grain prices but must be discarded. One miller visited in Quito, Equador, solved the problem by cleaning the wheat as it was being unloaded and returning the foreign material to the seller. He then bought the cleaned wheat that was left. The seller seemed to accept this practice, however it does require cleaning equipment at the point of sale.

Other objectionable aspects of foreign material are its affect on storability and handling and the possibility of producing off odors or flavors, or even toxicity. (Substantial amounts of toxic materials mixed with the grain would make the grain unacceptable.) Some materials such as wild garlic, may produce odors or flavors that would be unacceptable for human consumption but would still be suitable for animal feed. These materials should be noted so that the buyer will be aware of their presence.

The amount of foreign material present can be determined by sieving and hand picking the sample. The material separated can be weighed, the percentage amount calculated, and recorded on this basis. From this information the total weight of the foreign material can be determined and subtracted to find the weight of clean grain. Grains sold on a clean basis provide an adjustment in price according to the amount of foreign material present, also this counters any attempt to increase the

weight of the grain by adding foreign materials like sand or stones. This basic concept of adjusting for foreign material has been used throughout history in the marketing of grains.

When separating foreign material (particularly fine material) the selection of the proper sieves is all important. The size and shape of the openings will depend on the characteristics of the grain kernal such as its size and general shape. Some recommendations for sieve sizes for U. S. grains are given in Appendix I.

Insect Damage

Each year a considerable amount of the world grain crop is damaged by insects. There is a direct weight loss due to the materials eaten by the insects. Nutrient losses occur if, for example, the germ, which contains the most protein, is eaten preferentially. Germination is also reduced. Contamination with insect fragments, feces, webbing and ill smelling metabolic products is generally discriminated against.

Both the quantity and quality losses are important in the marketing system and need to be studied to see how they might fit into an inspection system.

Some quantity losses due to insects are compensated for by the loss in weight. Other material will be lost during handling, processing or preparation. Dust will make up a large amount of this and is readily detected at the bottom of a sample and will be removed by sieving. Although it might be argued that a loss of this type will carry its own discount, due to the reduced weight, a further discount is recommended

to discourage bad storage practices that allow insect development and to compensate for quality loss.

Quality losses may be of two forms. A nutrient loss will occur when portions of the kernel are removed. The amount of loss will depend on which part of the kernel is attacked. If the germ is removed then a larger portion of vitamins and proteins may be lost as compared to removal from the endosperm. The importance of this will depend to some extent on the usage, if it is to be milled where the germ is removed during processing, then the insect damage may not alter the usefulness of the grain.

Associated with insect damaged grain is the contamination of the grain by the presence of insects. The insect fragments, feces, webbing, etc., may cause health problems or off odors or tastes which could make the grain unacceptable to the consumer. The objectionable point to having insect damage in the sample of grain isn't so much the quantity loss but rather the hidden infestation and insect fras that will remain in the sample after sieving.

How then is insect damage identified in a sample? A definition, such as the one used in the U. S. grain standards found in the definitions section of this report, allows for discounting on the basis of internal infestation that may be present, but not necessarily for the amount of product lost. Product lost due to consumption is reflected by the reduced weight. The inclusion of insect fras is undesirable from a sanitation as well as aesthetic standpoint and some adjustment should be made to discourage contamination. It should be recognized that

some insect damage is bound to occur in grains that are stored for a period of time. Again through market surveys some base condition could be assigned and adjustments calculated from this.

As an example the survey may show that throughout the year the insect damage may vary from 0 at harvest to 20% at the end of the storage period. Generally the higher levels of insect damage will occur toward the end of the storage period. Therefore to encourage better storage practices the reference base may be set at 5% damage with a discount of 1% for each 2% damage greater than 5% and a premium of 1% for each 2% damage less than 5%. This discount should be verified by studying the discounts now applied by the consumer when buying grains in the markets.

It might be desirable to place an upper limit on the amount of insect damage that would be allowed in the grain. This limit could be set at whatever level of damage would cause the grain to have no value. We have no definite suggestions as to what this limit might be. In our opinion any grain that has been attacked by insects is still utilizable as animal feed and therefore would still have value. In many of the markets visited grains were found that were 50% or more insect damaged and were being sold as feed grains. If upper limits of acceptance were imposed then grains containing high levels of damage would possibly be mixed with sound grains until they were acceptable. If the suggested discount were applied to all levels mixing of grains would be no financial advantage.

Molds

Mold toxicity is one of the major concerns when dealing with moldy grain. Aflatoxins, produced by the mold Aspergillus flavus, have been shown to cause cancer in test animals, causing reduced production and even death. Ducklings, for example, are affected by the presence of 1 to 2 parts per billion. The death level is approximately 20 micrograms per 50 gram duckling live weight. "Aflatoxins are not destroyed by the temperatures of ordinary cooking or the heat processing of home or commercial canning. They can be inactivated or detoxified microbiologically or chemically, but the processes are not commercially feasible for most materials, and it is generally agreed that the best control is to harvest, store, handle and process raw materials and finished products of foods and feeds in ways that will prevent invasion by Aspergillus flavus." (4)

Aflatoxins can be detected and quantities present determined; however, most quantitative methods require sophisticated chemical laboratory facilities and trained technicians. The following is a brief description of four commonly used methods of aflatoxin detection from a Feedstuffs (15) publication.

Black Light: Cracked corn or screenings are viewed under long wave ultraviolet light (approx. 365 nm). Samples are checked for "glowers" or starchy endosperms which fluoresce a bright green-yellow (BGYF). The BGYF compound is not aflatoxin but a substance produced by the Aspergillus flavus fungus when growing on living seed. This compound will not be produced on dead seed. Corn may be cracked for testing with a cereal grain grinder.

This method is quick but only indicative of <u>Aspergillus flavus</u>. BGYF is not produced in dead seeds. The test is not quantitative and is only presumptive. The test should be used by only trained personnel since soybean fragments and other foreign materials may fluoresce.

<u>Minicolumn</u>: Ground corn is extracted with solvents and the extract washed through a column containing two absorbants. Migration and UV light are used for detection.

This method is quick but only semi-quantitative. It can be used as a go - no go measurement above 2 ppb. The short minicolumn test is not suitable for mixed feeds.

<u>Thin Layer Chromatography (TLC)</u>: Corn is extracted and the extract is placed on a thin layer chromatographic plate. UV light and migration compared with a standard are used for identification.

This method is slow and somewhat expensive; however, it is precise and accurate.

<u>Duckling Bioassay</u>: One-day-old ducklings are fed extracts suspected of containing aflatoxin for 3 to 5 days. Mortality or liver pathology are used for identification.

With this method the tissue tests (liver pathology) are very specific. Ducklings are very sensitive.

Identifying the moldy kernel is no easy straightforward task. Referring back to the definitions section, the provisions in the U. S. standards for identifying moldy kernels considers only those kernels that have been internally damaged by mold. External surface mold, if it has not internally invaded the kernel is not considered as mold damage. C. M.

Christensen (4), when talking about storage fungi, stated that "all of these fungi invade the germ or embryo of the seed preferentially, and sometimes exclusively. The embryo of cereal seeds contain much more oil than does the endosperm and therefore at a given relative humidity will have a lower equilibrium moisture content than does the endosperm." This indicates that the moisture content of the germ is slightly higher than the endosperm and would support mold growth when possibly the endosperm would be too dry. Thus, when looking for the presence of mold the germ should give a good indication providing the kernel is a whole sound kernel.

Mold presence within the germ would be indicated by discoloration and an unhealthy appearance. If there is any doubt as to the presence of mold, then the kernel should be cut open and inspected with a magnifier under good light. A magnifier of 10 to 15 power should be sufficient. By comparing with a sound kernel an inspector can determine the presence of mold with a minimum of training. Basically any mold present in the kernel will have the appearance of closely knit webbing with small puffy balls, severely molded germs appear dark as compared to mold free germs. A sound kernel will not have any of this. With experience an inspector will be able to determine moldy kernels quite readily.

These moldy kernels should then be separated and the amount determined. A substantial discount is suggested for moldy grains such as from 3% to 5% for each 1% damaged grain present.

This discount seems to be in line with observations made. For example, we found beans in the San Jose, Costa Rica, market that were being discounted 60% for approximately 30 and 50% moldy kernels. These were the only samples of moldy beans found in the market that day. A sample of surface molded corn was also observed in this market but no price differential was noted when compared to other mold free corn. Apparently the consumer did not consider the surface mold as a factor that would alter the value of the grain. This observation would strengthen our definition of moldy kernels to include only internal mold invasion of the kernel as damaged. The amount of mold damaged grains found throughout our investigation was low indicating that severely molded products do not generally enter the existing marketing channels.

It is felt that with this type of discount producers would be encouraged to take precautions to prevent mold growth in their grains. At first it was thought that a smaller discount with a maximum limit of moldy kernels would be acceptable, but this could encourage mixing of moldy grains with sound grains. For example, if the limit of 15% moldy grains were imposed, then any grains containing more than this amount would be mixed with sound grain so that it would not exceed the acceptable limit. If, however, a 4% discount for each 1% moldy were applied, then at the 10% moldy level the discount would be 40% and at 25% moldy the discount would be 100%. If this 25% moldy grain were mixed and sold the situation illustrated in Table 4 would prevail. Here two 100 Kg lots of grain are compared. One free from mold and the second with 25% moldy. The total

TABLE 4. COMPARISON OF GRAIN PRICES WITH DIFFERENT AMOUNTS OF MOLDY KERNELS (price $.10/Kg)*

	Grain	Moldy	Adjustment	Price
1.	100 Kg	-0-	-0-	$10.00/100 Kg
2.	100 Kg	25%	-100%	$ 0.00/100 Kg
3.	200 Kg	12.5%	- 50%	$ 5.00/100 Kg

*Discount 4% for each 1% mold damage.

amount of money received for selling the grains separately and combined is the same showing no advantage to mixing the grains.

Mixed Grains

The presence of mixed grains in markets studied varied widely from place to place. In Equador, beans were beans; as long as the cooking quality was similar, varieties were mixed without any value change. In Colombia, on the other hand, any mixing of beans would result in lower prices. This is an example of consumer preference and the results due to this preference.

The problem of mixed grains can be considered in three categories:

1. Different class of the same grain mixed,
2. Grains with similar characteristics mixed, and
3. Dissimilar grains mixed.

Examples of mixing different classes of the same grain would be a soft wheat mixed with durum wheat, red beans mixed with black beans or white corn mixed with yellow corn. The value differentiation will depend to a large extent on the end use of the grain. Wheat millers would object to having a soft wheat mixed with a very hard wheat due to the different milling characteristics of the wheats. With the corn, if it is to be used in animal feed, the objection of having a mixture may not be as strong as long as the nutritional level of the grains are similar. However, for human consumption, there may be a flavor or cooking difference that would cause a mixture of the two corns to decrease in value.

Grain of similar physical characteristics can become mixed naturally due to similar growing conditions. For example, wheat may have some rye or barley mixed due to mixed seed or carry over from previous crops. Some mixing of this type may be normal for certain market areas. The reduced value caused by the inclusion of other grains again depend to some extent on the end use of the grain. The important point to keep in mind is that the foreign grain that is included does have some value. If it has been mixed naturally, then the grains most likely have some similarities. This type of mixing will be separate from the third type of mixing due to this similarity.

The third area to consider is the mixture of dissimilar grains. An example of this would be corn in rice or possibly beans in wheat. Mixtures of this sort are due to negligence or purposeful mixing to increase the weight of the grain being sold. This type of mixing needs to be discouraged and can be, if a proper penalty is applied.

How then can a discount schedule be developed that will reflect the value change due to the three different types of mixing without over penalizing a certain area? For the mixtures of dissimilar grain, as in the third category, a discount representing the weight of the foreign grain is suggested. In other words, we are treating the grain as foreign material which it essentially is. Thus, by discounting one percent for each one percent found in the sample, no advantage is gained by the seller to add these materials to increase the weight.

Where grains of similar characteristics such as wheat and rye are mixed we feel some attention should be given to the

fact that these grains do have some value. Discounting the same as above would give no credit to this value. Therefore, for different varieties of the same grain and for similar grains that are mixed we would suggest a discount of one percent for each two percent of the other grains. Exactly which grain will be put into each category may vary from place to place. This definition is left for local decision.

Damaged Kernels

Aside from factors previously discussed, there may be the need for a factor or category for other damages found in the sample. This would include such damages as cracked and broken kernels, sprouted, heat damaged, badly weather damaged, green kernels and any other material damage that may affect the quality of the grain. The specific damages included in the factor will depend on the type of grain, its usage and consumer preference. For example, cracked or broken corn may not bother the consumer much because it is generally ground before it is consumed. However, broken kernels present in rice generally decrease the price of the rice in the market. Some of the points may have little affect on the grain quality but may affect the storability or the suseptibility of the grain to other damages. For example, grains that have been cracked or broken due to rough handling or improper drying are more easily invaded by moisture, insects and micro-organisms. If the grain is to be stored for a period of time, more care would have to be taken to insure against further quality deterioration.

The damaged kernel category may have one or more factors incorporated in it depending on the type of grain, its usage,

local conditions and consumer acceptance. The idea behind this category is to include in it those points which are generally not a problem but are occasionally found in grain. Defining these points will, of course, vary from place to place, some sample definitions are given in the definitions section of this paper.

The adjustment made for the damaged kernel factor is suggested at 1% for each 2 - 3% damage found. Through market surveys, again, a reasonable base point and discount rate can be determined.

Odor

The odor of grain can tell much about the condition of the grain. A musty or earthy odor may indicate that the grain was held in damp conditions and should be carefully inspected to see if damage has occurred. If chemicals have been applied to the grains the odor of these can often be detected by a trained inspector. If chemicals are found then some investigating should be done to determine what the chemical is and if it will be harmful. Burke and Pfost (3) pointed out that in Rwanda, where DDT was used in coffee production to control insects, a farmer would occasionally treat his stored grain with the DDT. This grain was then refused. Another traditional insect control used in Rwanda is cow urine mixed with ashes and applied to the grain; this grain is also refused, in this case due mostly to the odor present.

Musty or sour odors in the grain are the result of mold growth or fermentation and heating. Both indicate a deterioration in the grain that may lower the quality. In the United

States and other countries a point included in odors is the commercially objectionable foreign odors. These are odors that result from the grain absorbing odor from other commodities that may have been shipped in the same container. In wheat, many of these odors will carry through into the finished flour, with feed grains the odors may adversely affect the palatability.

Grain should be tested (by smelling) for these odors before the sample is cleaned or sieved or before the grain is exposed to the air for any considerable length of time. If, for any reason, this cannot be done, then a representative sample should be kept in an air tight container until conditions permit the test to be made properly.

Toxic Materials

To safeguard against the inclusion of treated seed (particularly mercury treated seed), poisonous seeds (such as crotolaria or jimson seed) and other toxic materials the inspection system needs to recognize this factor and deal with it according to the problem. Toxic seed presence varies from region to region and inspectors will have to be trained according the local conditions. In some cases local farmers may not realize the danger to human or animal health as the result of having treated seed mixed with their grain or using certain types of insecticides on their stored grains. In Rwanda, the Catholic Relief Services will refuse to take any grains thought to have been treated with DDT. Included here would be any insecticides, such as DDT, that are not approved for use on food materials.

If the grain shows the presence of any of these toxic materials then it should be refused.

Test Weight

Test weight or weight per unit volume is a factor that has been included in many inspection systems now in use. This measure is thought to provide an index to the plumpness of the grain which could then be used to determine its relative value as compared to grains of another test weight. Millers consider this factor useful in determining the expected milling yield (the amount of flour obtained from a lot of grain); however, work done to establish the relationship between test weight and flour yield shows that it is only a rough indicator at best and for some classes of wheat has no significant meaning. "The influence of various factors on the relation between test weight and flour yield make this index unreliable. The weight of 1,000 kernels is sometimes used in relation to flour yield potentials; it is, however, generally a rough indicator much like test weight." (1)

Test weight of a sample of grain will vary with the moisture content, foreign material present as well as the plumpness of the grain. It may be questioned then as to its usefulness in determining the quality of the grain.

An increase in moisture content will tend to decrease the test weight of a sample of grain. This is due to the swelling of the kernels at a faster rate than the rate of gain due to the addition of moisture. If two samples of the same grain were compared by test weight with the only factor different being moisture content, then the test weight of the dryer grain

would be higher. If an adjustment is made to compensate for the moisture difference, as suggested earlier, then any further adjustment would be redundant.

Foreign material is a case similar to moisture content in its effect on test weight. Here materials such as stones and sand, which have a greater density than the grain, will tend to increase the test weight. It has been suggested earlier that an adjustment be made for foreign materials. Any further adjustment for test weight which has been influenced by foreign material in the grain would again be redundant.

In a publication (14) concerning proposed revisions in the United States grain standards it was stated: "Pound for pound the utility value of high test-weight corn for livestock feeding or for use in the so-called corn-products industries is usually not considered much, if any, greater than that of low test-weight corn, with the possible exception of immature corn that is of very low test-weight. So far as the utility value of corn for livestock feeding is concerned, feeding tests of high test-weight and low test-weight corn have shown sometimes that the low test-weight corn was of superior value because of its relatively higher protein quality." The use of test weight to relate a quality condition of a grain seems to have little or no value. Therefore it is suggested that this not be used in an inspection system as a means of pricing a grain. If however, there is interest in knowing the test weight it could be reported along with any other information about a grain.

Protein

The nutrient value of grains is important and need some additional comments. With increasing demands on present grain supplies by growing populations it is important to utilize the grains to their best advantage. If the protein content of the grains were known then these grains could be used to more exactly fulfill the nutritional requirements of both man and animal. If, for example, two samples of black beans (a good protein source for humans) varied in protein by 5 percentage points, then it would be reasonable to expect a better price out of the higher protein beans. It would take less of these higher protein beans to be nutritionally equal to the lower protein beans.

This protein difference in grains is recognized in many parts of the world. For example in the United States a premium is paid for high protein wheat. This however is outside the official Grain Standards. There is discussion of incorporating protein in the official standards but as of this writing protein is not a grading factor in the United States. It is however quite commonly reported along with the grades of wheat for example.

One major drawback to using protein content as a grain quality factor is the method of determination. The most accurate methods take time and good laboratory facilities. This would require that grains would have to be held separately until the determination could be made. Any of the quick methods of protein determination require expensive equipment, not to mention the training of technicians to make the determinations.

As important as protein may be it seems it is not practical, at this time, to recommend it as a quality factor. Possibly some time in the future, when equipment or techniques are developed that would be both economical and quick, protein should be included as a quality factor.

Milling Yield of Rice

Empty kernels and brokens are a special problem in rice. Consumers object to broken kernels in rice more than any other grain. No matter if we are talking about short or long kernel rice, one of the major price points is the amount of broken kernels present. The amount of brokens will depend to a large degree on how the rice is handled and if it is dried properly. Rice that has been dried too rapidly or at too high a temperature will tend to break up during milling.

When dealing with rice then, some means of determining how the rice will mill and what milling yield can be expected may be useful. This is most commonly done with a small test mill that actually mills a sample of the dried rice. The milled sample can then be cleaned and the brokens, etc., determined from this and the milling yield calculated.

This milling test will also help with the empty kernels problem. These are kernels of rice that, due to variety, environment or insects, did not fill the hull. The kernel consists of nothing more than the empty hull. This hull is useless as a food source and therefore has no value as such.

During a milling test these empty hulls will be broken up and removed with the rest of the hulls leaving only the kernels of rice. These empty kernels can be picked out by hand, but

not easily. It takes experience to separate the full and empty kernels of rice without testing each kernel to see if it contains a seed.

Test milling a sample of rice from each lot of grain sold may not be possible especially when dealing with small lots of a few sacks. An alternative to the milling test for empty kernels would be test weight of the rough rice. If test were run on cleaned, moisture equivalent rough rice, the inclusion of empty kernels would lower the test weight. In remote areas or when dealing with small lots of rice this test weight might be utilized in the place of a milling test. This will not, unfortunately, give any indication as to broken kernels in the sample. Through studying the varieties grown, and handling methods in an area some idea can be developed that will indicate the amount of brokens that can be expected.

RECOMMENDATIONS

The grain inspection system should be designed to serve as a marketing tool whenever it is used. To do this it must supply information about the grains in the market in such a manner as to be easily understood by those persons concerned. The system should have incorporated into it a means of paying premiums for high quality and discounting for the lower quality produce in a fair and equitable manner. The adjustments need to be made so that the seller is aware of why the adjustments are being made and, thereby, can see ways to improve the quality of his grain. The adjustments need to be applied throughout the marketing channels to assure that the quality features of the grain are reflected to the producer and consumer alike.

Simplicity is the key to making the inspection system useful in all parts of a country. We have recommended quality factors that can be determined with a minimum of equipment. The equipment used should be kept as simple as possible to assure reasonably accurate results from all buying points found throughout a country, no matter what size or how isolated they may be. All of these buying points will need to be staffed with technicians capable of operating the equipment and implementing the inspection system. The simpler the system is designed the less training will be needed to keep the technicians up to date on procedures and any changes. Keeping the inspection system simple and uncomplicated also helps when inspecting small lots such as a few sacks. Many times conditions

will not permit lengthy inspection or complicated procedures. Therefore, it is to the advantage of the agency doing the inspection to keep these to a minimum.

The quality factors an inspection system is based on should reflect the grain quality as it exists in the marketing system. When developing an inspection system or reviewing an existing system it would be meaningful to evaluate the grains as they now exist in market places. From this information the value of the different quality factors and their base points can be determined so that it applies to that particular market area. For example, if the inspection system were being developed by a country then the information gathered about the grains would give an indication as to what quality factors the producer, merchant and consumer felt were important.

To gain an insight into grain quality conditions as they exist, an extensive market survey is almost mandatory. This survey would involve sampling and inspecting all sources of grains into the markets, large and small. All of these sources must be represented to get an over-all view of problems and conditions that are present. It would be a grave injustice to select quality factors that represent only part of the whole marketing system. If the inspection system isn't representative of the whole, then the resistance to its implementation will be greater.

Conducting these surveys in a representative manner is very important, not only with respect to grain sources but also with respect to time of year. Grain quality changes throughout the year due to the necessity of storing it. A market

survey will give an indication as to how storage will effect the grain crop. This information can in turn be used to help reduce storage losses by giving incentives, through the inspection system, to preserve grain quality.

The market survey must include 1) representation from all sources of grains into the market; 2) inspection of samples for quality tests including moisture content, foreign material and other damages; 3) determination of the price differential in present use for each quality factor.

Class Differentiation

Grains must be compared within their respective classes to be successfully evaluated. This point of recognizing different classes is important. To compare durum wheat used in pasta products with soft wheats used for pastries would be useless. The end use of these two wheats are different, therefore, the market prices will not be the same. Class differences must be recognized when making quality determinations.

Relating Value and Quality Factors

Table 5 can be used to illustrate how each of the quality factors could be used to determine the value of a grain. Corn is used in this example but the major difference for other grains would be to reassign the base conditions or discounts and premiums. In this example, base conditions were chosen for each quality factor. With each situation these base points would be determined after the market survey was completed and analyzed. These base points could be chosen in different manners: 1) All samples could be adjusted to 0% tolerance. This would basically mean that for any factor found in the sample a

discount would be made. Psychologically, we feel, this may not provide the incentive necessary to improve quality because it is nearly impossible to have completely clean and damage-free grain; therefore, everytime grain is sold some discount would be made. 2) Base points could be set high thereby providing premiums for all but very low quality. This again may have its bad effects. The producer may feel that since he is receiving a premium then no further improvement is needed. 3) Choose base points that reflect the condition of a majority of the grain. With this situation premiums are within reach of the producer if he can improve the quality of his crop, and discounts aren't so heavy that they have an adverse affect on him.

How these factors are applied is illustrated with the help of Table 6. In this example a sample of grain is inspected and an inspection certificate filled in with the appropriate data. Once the condition of the grain is known, in this case moisture content 15%, foreign material 3%, etc., then the premiums and discounts can be calculated based on the conditions of Table 6. For example, insect damage is 3%, this is 2% below the base point. From Table 5 the premium is 1% for each 2% insect damage less than the base point. Therefore a premium of 1% is given. Note a 1% discount for foreign material.

A table of this type, filled out and given to the producer will show him exactly where improvements can be made to improve the quality and price of his grain.

When an inspection system is developed, the provision for revision of the system should be included. However, the revision shouldn't be too often nor without just cause. Any system

should be tested for an extended period and then, with the data collected during this time and representatives from all parts of the system, a review of its strong and weak points made. Adjustments to the system can be made as needed.

TABLE 5. SUGGESTED VALUE FOR GRAIN QUALITY FACTORS
CORN

Factor	Base Condition	Premium	Discount
Moisture Content	13%	1% for each 1% lower than base	1.15% for each 1% higher than base
Foreign Material	2%	1% for each 1% lower than base	1% for each 1% higher than base
Insect Damage	5%	1% for each 2% lower than base	1% for each 2% higher than base
Moldy	1%		3% for each 1% higher than base
Damage	2%	1% for each 2% lower than base	1% for each 2% higher than base
Mixed Grains	2%	1% for each 2% lower than base	1% for each 2% higher than base
Toxic Material	100% discount for the presence of toxic materials		

TABLE 6. INSPECTION CERTIFICATE
CORN

Owner

Date

Location

Weight of Grain

Method of Transport

Method of Sampling

Sampler

		Premium	Discount
Moisture Content	15%		-2.2%
Foreign Material	3%		-1%
Insect Damage	3%	1%	
Moldy	-0-		
Damaged	2%		
Mixed Grain	1%	.5%	
Total		1.5%	-3.2%
Total Adjustment	- 1.7%		

Price paid: 1000 Kg x $.10/Kg - (1000 Kg x $.10 Kg) .017 = $98.30 or (1000 Kg) (1 - .017) x $.10/Kg = $98.30

CONCLUSIONS

A system for grain quality determination should be useful, easily understood, fair and economically justified. To give the system an unbiased position when a third party is incorporated into the two party (buyer and seller) system of present, the buyer and seller must be satisfied that the third party has no vested interest in the outcome of the inspection results.

Quality factors need to be truly related to the grain value. To incorporate factors that the market place has not recognized as important may lead to a general rejection of the system. The definitions of quality factors must be precise enough so misunderstandings are a minimum and written plainly enough to be understood by all those using them.

Numerical grade designations as used in international trade are not necessary in an in-country inspection system. Systems other than the numerical grade designation are successfully being used in such countries as Australia, Tunisia, Venezuela, Rwanda and others. This system may need to be modified for exporting grain but no problems are foreseen with buying in country on a quality basis and exporting according to agreement.

A good quality determination system, run properly, can help preserve the quality of the grain in the market. This is done by a system of rewards and discounts that truly reflect grain value.

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APPENDIX I
SIEVES

The following sieves are those used in the United States for inspecting grain. This list is not meant as a sieve size recommendation but merely as an example of what is in use. Due to the different grains grown and growing conditions found throughout the world the sieve sizes needed may vary. The following list may provide a place from which to start when selecting sieve sizes for a particular application.

Grain	Sieve	Use
Wheat	.064 x .375 in (1.63 x 9.53 mm) Oblong hole	Determination of broken and shrunken kernels
	.083 in (2.10 mm) Round hole	Removing small seeds
Corn	12/64 in (4.76 mm) Round hole	Broken corn and foreign material
Soybean	8/64 in (3.18 mm) Round hole	Foreign material determination
Grain Sorghum	2.5/64 in (1.0 mm) Round hole	Foreign material determination
Rice (rough)	.0605 x .5 in (1.54 mm x 12.7 mm) Oblong hole	Foreign material determination
	.1406 in (3.6 mm) Round hole	

APPENDIX II
SAFE MOISTURE LEVELS

When grains are to be stored for a period of time some attention must be given to the condition of the grain to assure against spoilage during storage. Moisture content and temperature of the grain are important considerations we feel need some further explanation as to their role in grain quality preservation.

To prevent mold growth in stored grain the common practice is to dry grain to a moisture level that will not support the development of mold. Table 7 lists some of the common storage fungi and the minimum relative humidity that will support growth and development of the fungi. Note that this table was developed using temperatures of 26° C to 30° C. Mold growth is temperature related as well as moisture related. This is an important concept when trying to store grain in hot weather climates. If the hottest month has a mean daily temperature above 30° C the safe storage moisture content should be reduced to prevent mold growth.

Table 8 gives the equilibrium moisture content (E.M.C.) at various relative humidities (R.H.) for some grains. This is the moisture content that the grain would reach if allowed free contact with air at the grain R.H. From table 7 we will see that grain at E.M.C. with 70% R.H. air will not allow most storage fungi to develop. From Table 8 the 70% R.H. corresponds to the 13.5 - 14.5 moisture content in wheat, corn and

sorghum. At temperatures above 30° C the E.M.C. would be lower for the same relative humidity. Again, if the storage period contains a month with temperatures above the 30° C point then the grain should be stored at a lower moisture content to protect against mold development.

Even though the average moisture content of a bin of grain is below the safe moisture level the possibility of heating is still present. This may be caused by temperature differences within the grain bin causing moisture migration (from warm to cool) thus creating a point in the bin where the moisture content is above the safe limit. This temperature difference may be caused by a number of conditions, one would be from seasonal temperature differences. That is when the grain is harvested in the hot season and put into storage. When the cooler season arrives, the outside temperature drops lower than the inside grain temperature thus causing a temperature difference. Another condition that does occur is the warming of grain next to the bin wall due to direct sunshine. This will cause high temperatures next to the bin wall thus forcing moisture to move into the grain mass. This moisture will move until it meets the cooler grain toward the middle of the bin, thus causing high moisture content at that point.

Mixing grain of different moisture contents to obtain an average content is a risky practice. Kernels of grain from separate lots approach, but never attain a common moisture level. As a result, kernels from the grain lot with highest initial moisture content may not reach a safe moisture level, even though the average moisture content of the entire grain

mass may be at a level that would be acceptable if the moisture were uniformly distributed.

Table 9 shows relative humidity equilibrium content for shelled corn due to desorption (losing moisture) and absorption (gaining moisture). The difference of the moisture contents is due to the hysteresis effect. Thus if grains were mixed and left in storage without periodic inspection spoilage may occur from the higher moisture grain. It is a better practice to dry all grains to a safe moisture level than to over dry some of the grain and mix it with higher moisture grain to get a common moisture level.

Once a safe moisture level is established all grains can be bought and sold by adjusting moisture to this point. Methods for adjusting are discussed under moisture content in this paper. This point should not be confused with the limit of acceptance which will vary from place to place according to drying facilities, transportation and such.

TABLE 7. MINIMUM RELATIVE HUMIDITY FOR THE GROWTH OF COMMON STORAGE FUNGI AT THEIR OPTIMUM TEMPERATURE FOR GROWTH (26° - 30° C) (4)

Fungus	Minimum Relative Humidity
Aspergillus halophilicus	68
A. restrictus, Sporedonemn	70
A. glaucus	73
A. candidus, A. ochraceus	80
A. flavus	85
Penicillium, depending on species	80-90

TABLE 8. MOISTURE CONTENTS OF VARIOUS GRAINS AND SEEDS IN EQUILIBRIUM WITH DIFFERENT RELATIVE HUMIDITIES AT 25^{o} - 30^{o} C (4)

Relative Humidity	Wheat, Corn Sorghum	Rice		Soybeans	Sunflower	
		Rough	Polished		Seeds	Meats
65	12.5 - 13.5	12.5	14.0	12.5	8.5	5.0
70	13.5 - 14.5	13.5	15.0	13.0	9.5	6.0
75	14.5 - 15.5	14.5	15.5	14.0	10.5	7.0
80	15.5 - 16.5	15.0	16.5	16.0	11.5	8.0
85	18.0 - 18.5	16.5	17.5	18.0	13.5	9.0

TABLE 9. DESORPTION AND ADSORPTION MOISTURE EQUILIBRIUM CONTENTS (% WB) OF SHELLED CORN AT 72° F (2)

R.H. %	Desorption	Adsorption
88.5	24.2	23.4
67.6	16.5	15.2
46.5	12.9	11.5
25.8	9.8	8.0
9.4	7.0	5.6

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DEVELOPMENT OF GRAIN STANDARDS IN DEVELOPING COUNTRIES

by

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B. S., Oregon State University, 1970

AN ABSTRACT OF A MASTER'S THESIS

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The grain inspection system should be designed to serve as a marketing tool whenever it is used. To do this it must supply information about the grains in the market in such a manner as to be easily understood by those persons concerned. The system should have incorporated into it a means of paying premiums for high quality and taking discounts for the lower quality produce in a fair and equitable manner. The adjustments need to be made so that the seller is aware of why the adjustments are being made and, thereby, can see ways to improve the quality of his grain. The adjustments need to be applied throughout the marketing channels to assure that the quality features of the grain are reflected to the producer and consumer alike.

Simplicity is the key to making the inspection system useful in all parts of a country. We have recommended quality factors that can be determined with a minimum of equipment. The equipment used should be kept as simple as possible to assure reasonably accurate results from all buying points found throughout a country, no matter what size or how isolated they may be. All of these buying points will need to be staffed with technicians capable of operating the equipment and implementing the inspection system. The simpler the system is designed the less training will be needed to keep the technicians up to date on procedures and any changes. Keeping the inspection system simple and uncomplicated also helps when inspecting small lots such as a few sacks. Many times conditions will not permit lengthy inspection or complicated procedures. Therefore, it is to the advantage of the agency doing the inspection to keep these to a minimum.

The quality factors an inspection system is based on should reflect the grain quality as it exists in the marketing system. When developing an inspection system or reviewing an existing system it would be meaningful to evaluate the grains as they now exist in market places. From this information the value of the different quality factors can be determined so that it applies to that particular market area. For example, if the inspection system were being developed by a country then the information gathered about the grains would give an indication as to what quality factors the producer, merchant, and consumer felt were important.

To gain an insight into grain quality conditions as they exist, an extensive market survey is almost mandatory. This survey would involve sampling and inspecting all sources of grains into the markets, large and small. All of these sources must be represented to get an over-all view of problems and conditions that are present. It would be a grave injustice to select quality factors that represent only part of the whole marketing system. If the inspection system isn't representative of the whole, then the resistance to its implementation will be greater.

Conducting these surveys in a representative manner is very important, not only with respect to grain sources but also with respect to time of year. Grain quality changes throughout the year due to the necessity of storing it. A market survey will give an indication as to how storage will effect the grain crop. This information can in turn be used to help reduce storage losses by giving incentives, through the inspection system, to preserve grain quality.

The market survey must include: 1) representation from all sources of grains into the market; 2) inspection of samples for quality tests including moisture content, foreign material, and other damages; 3) determination of the price differential in present use for each quality factor.

Grains must be compared within their respective classes to be successfully evaluated. This point of recognizing different classes is important. To compare Durum wheat used in pasta products with soft wheats used for pastries would be useless. The end use of these two wheats are different, therefore, the market prices will not be the same. Class differences must be recognized when making quality determinations.

Quality factors we have found to be important throughout the world are moisture content, foreign material, insect damage, moldy kernels, mixed grains, and toxic materials. Other damages do occur but are not as prevalent or are particular to certain areas. Simple discounts can be made to adjust the price paid for a lot of grain to reflect its condition as compared to a dry, clean, damage free lot. By using adjustment for each quality factor according to how it affects the grain the producer can see ways of improving the quality of his produce and thereby reducing any discounts that may apply.

A system for grain quality determination should be useful, easily understood, fair and economically justified. To give the system an unbiased position when a third party is incorporated into the two party (buyer and seller) system of present, the buyer and seller must be satisfied that the third party has no vested interest in the outcome of the inspection results.

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